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無病毒豇豆種子之生產與應用

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摘　　要

張清安、楊佐琦、詹竹明、陳金枝　1994　**無病毒豇豆種子之生產與應用**　植保會刊　36:313-325.

豇豆 [*Vigna unguiculata* (L.) Walp. ssp. *sesquipedalis* (L.) Verdc.] 爲本省重要之夏季蔬菜。栽培過程中極易罹患病毒病而影響豆莢之產量與品質。黑眼豇豆嵌紋病毒 (Blackeye cowpea mosaic virus, 簡稱 BlCMV) 及胡瓜嵌紋病毒 (Cucumber mosaic virus, 簡稱 CMV) 是危害本省豇豆之最主要病毒。感病植株之部分種子有帶病毒現象，發芽後即成爲田間初次感染源，再經人員操作及蚜蟲媒介可造成病害流行，影響植株之生長與結莢。本研究由豇豆品系〝三尺青皮〞之植株中以 BlCMV 及 CMV 之抗血清篩選出無病毒單株，再栽培於網室中採收種子而爲無病毒原原種。嗣後由種苗改良場續以田間網室大量採種，供農民栽培。以此模式所生產之種子經抗血清檢定證實不再帶有上述二病毒。爲了解無病毒種子於田間栽培後對病毒病之防治效果，分別於霧峰、高樹、莿桐及溪洲共進行四次田間栽培比較試驗，結果發現栽培農民自行保留之帶病毒種子試區在栽培末期之病毒病發病率均早已達到100%，而栽植無病毒豇豆種子試區之發病率僅爲30～72%，顯示具有延遲病毒病發生之效果。各無病毒種子試區之產量不僅較對照試區提高11～74%，而且所生產之豇豆豆莢之平均單莢重及長度也有顯著提高。由於病毒病發生之減輕，促成豇豆豆莢產量與品質之提升，上述試區農民之收益比栽植帶病毒種子之試區提高32～74%。

(關鍵詞：豇豆、病毒、無病毒種子、病毒防治)

緒　　言

豇豆 [*Vigna unguiculata* (L.) Walp. ssp. *sesquipedalis* (L.) Verdc.]，台灣俗稱菜豆。性耐高溫多濕，爲本省重要之夏季蔬菜[1]。危害豇豆生育之病害種類爲數不少[3]，但是防治上最爲困難的應屬造成系統性感染的病毒病害[2,3]。已經確定在本省危害豇豆之病毒種類有黑眼

豇豆嵌紋病毒(Blackeye cowpea mosaic virus, 簡稱BlCMV)[2,9]、豇豆蚜媒嵌紋病毒(Cowpea aphid-borne mosaic virus, 簡稱CAMV)[5,9]及胡瓜嵌紋病毒(Cucumber mosaic virus, 簡稱CMV)[2,9]等三種。三者均可經由機械傷口及蚜蟲媒介而傳播[2,5,7,9]。單獨感染BlCMV或CMV之豇豆植株葉片會出現濃綠不均之嵌紋病徵，通常對生育影響不大[2]。但是當BlCMV與CMV發生複合感染，則病徵會由嵌紋轉爲皺葉嵌紋，葉片變形縮小，植株生長停頓，豆莢扭曲變形，甚而出現壞疽[2]。由於此二種病毒間發生協力作用(Synergism)，致使此二種病毒濃度均比感染單一病毒之豆株提升甚多，此種現象導致蚜蟲傳播之成功率大增，使病害之流行更爲快速[2,9]。CAMV感染豇豆時會造成較感染BlCMV之植株更爲嚴重之黃化嵌紋病徵[5]。不過CAMV在1983年被報告後在本省田間就從未被再發現，原因不明[9]。由感染病毒之豇豆植株上所採得之種子具有帶病毒現象[4,7,9]，播種發芽後即成爲初次感染源，再經由農民摘心、除側芽等操作及蚜蟲媒介傳播可於生育初期造成病害流行[4,7,9]。豇豆爲自交作物，本省農民傳統上均自行留種，因此導致帶病毒種子可以代代相傳。本研究室經長期觀察，已經確定帶病毒種子乃造成本省豇豆病毒病年年嚴重發生之主要因素(張清安，未發表資料)。故研發無病毒種子之育成技術，並進行田間實際栽培試驗，確定無病毒種子有延遲病害流行，提高產量品質與農民收益之顯著效果。本文即詳述無病毒豇豆種子之生產程序與栽培後對防治病毒病之效果評估。

材料與方法

供試豇豆品系

本研究進行無病毒化之豇豆乃由屏東里港地區農民所保留之品系中選出之〝三尺青皮〞品系。此品系與本省栽培最普遍之〝青皮紫尖〞品系外型幾不可分，其豆莢呈翠綠色，種皮呈黑色，豆莢尾端具紅紫色特徵，長度較青皮紫尖者平均高出10公分以上。研究過程中進行之田間比較試驗均以〝青皮紫尖〞品系作爲對照品系。

病毒檢定

本試驗所有病毒檢定均以過去曾報告之間接型酵素聯結抗體法(Indirect enzyme-linked immunosorbent assay, 簡稱Indirect ELISA)[8]進行，使用之抗BlCMV及CMV病毒血清爲本實驗室自行製備者[9]。行豇豆種子之病毒檢定時乃將待檢之豇豆種子播種於含4號蛭石之育苗盆中，於室溫下催芽，發芽後取下一片初葉(Primary leaf)供病毒檢定，植株則仍可繼續保留栽培。

栽培無病毒豇豆種子之防治效果調查

爲了解無病毒種子於田間實際栽培後對病毒病之防治效果，民國80年4月在農試所霧峰農場進行第一次田間試驗，無病毒種子與對照青皮紫尖種子各栽培一分地，其中對照種子乃購自霧峰當地種子行，經檢定後確定其種子帶病毒率約爲10%。二試區相隔約100公尺以降低相互干擾可能性，每一試區爲25×40公尺，畦寬1公尺，南北走向，畦溝寬30公分。種子採直播方式播種，每穴二粒，每畦二行，發芽後保留一株較健壯者繼續栽植。當豆株約10公分高時插立竹籬支柱，其他栽培管理均採陳[1]之方法進行。播種後每隔20天調查病毒病發病率消長情形至收穫爲止。調查時每一試區逢機抽檢10畦，每畦逢機採10個標本共100個標本，以BlCMV及CMV抗血清檢定感染病毒之標本總數計算該次調查之發病率。豆莢成熟期每2～3天

採收一次，統計產量供評估防治效果之參考。若爲估計病毒病發生後對豆莢品質之影響，則由試區分別逢機抽檢100條豆莢，計算其長度及莢重作爲評估品質之依據。

第二次無病毒豇豆種子田間栽培效果評估於民國81年9月在雲林莿桐進行。試區設計與前者相同，唯試驗區與對照區南北相隔約200公尺，對照區種子爲當地農民自行保留之青皮紫尖品系，其帶病毒率經檢定約爲3%。試區栽培管理委託農民以當地傳統方法進行，與前一試驗不同處在於農民將種子集中播種育苗後再行定植於田間。病毒病之發生調查方式同前，本試驗於苗定植後10、70、83、90及130天共調查五次。豆莢成熟期委託農民依實際需要進行採收、販賣並統計產量與收益。

除前述二試驗外，本研究於81年8月及82年2月分別在屏東高樹及彰化溪州兩地委託農民進行無病毒豇豆種子與當地品種種子之栽培比較試驗，試驗區之規劃與設計均與前述試驗相同，試驗種子區與對照種子區之距離則依當地情形調整，高樹試驗兩試區相隔50公尺而溪州試驗兩試區則相隔約150公尺。豆莢成熟後亦委託農民採收、販賣及統計產量與收益。

結　　果

無病毒豇豆種子之繁殖

將由田間篩選所得之三尺青皮品系種子於溫室內播種，發芽後先將初葉上出現病徵之幼苗淘汰，剩餘外觀健全植株則單株分別移入大植缽中繼續培植。爾後以抗BlCMV及CMV之二種抗血清每隔十天對每一單株進行一次檢定，共進行三次。淘汰正反應之帶毒植株，其餘植株則移於防蟲溫室內培植至收穫種子爲止。期間定期噴施藥劑以杜絕蚜蟲傳染。若有可疑病毒病徵出現，立即隔離並以抗血清檢定，若證實爲病毒病則加以銷毀，所收穫種子即爲無BlCMV及CMV病毒之豇豆原原種。79年6月將部份原原種種子播種栽植於田間簡易網室內，依上述相同步驟進行病毒檢定，至種子收穫止並未發現任何植株感染病毒，結果共收穫種子3公斤即爲無病毒三尺青皮豇豆品系之原種。

大量無病毒豇豆種子之生產於80年夏作及81年春作分別於種苗繁殖改良場進行了二次大面積網室栽培，80年夏作並以一般市售之青皮紫尖品系於網室外栽培作爲對照，結果由於夏作氣候較適合豇豆生長，所繁殖種子量較春作高出75%(表一)。栽培過程中曾進行數次抗血清檢定，及每週例行之病徵觀察均未發現有任何帶毒植株，所收穫之種子經檢定後亦未發現有帶毒現象。反之網室外對照區青皮紫尖品系植株後期發病率達100%，其種子產量亦較無病毒種子區減少75%(表一)，而且所採種子經檢定帶病毒率爲8%。

栽培無病毒豇豆種子對病毒病發生率之影響

第一次栽培無病毒豇豆種子對病毒病之防治效果調查於農試所進行，結果發現帶毒種子對照區於播種發芽後病毒病即快速蔓延，40天左右發病率已達50%，約100天時達100%發病(圖一B)，此試區在第120天時大部分植株已老化死亡，無採收豆莢價值(圖二B)。而無病毒種子試區病毒病之發生明顯延遲，播種後40天才開始發現病株，且發病速率較對照區緩慢，第120天時仍樹勢茂盛結莢豐碩(圖二A)，試驗結束時發病率僅53%(圖一B)。第二次田間試驗於雲林莿桐進行，其結果與前一試驗類似，無病毒種子區發病較緩慢，定植後130天試驗

表一、不同栽培季節對繁殖無病毒豇豆種子之影響

Table 1. Effect of different cultivation seasons on the production of virus free asparagus bean seeds[1)]

Influence analysed	Cultivation season			
	Spring		Summer	
	VF-seed	Control	VF-seed	Control
Av. pod length (cm)	55.6	–[2)]	80.2	54.3
Av. seed No. per pod	16.3	–	15.6	15.4
Seed yield (Kg/ha)	40	–	70	40
Weight per 10^3 seeds (gm)	1520	–	1850	1780
Virus incidence (%)	0	–	0	100
Seed-borne percentage	0	–	0	8

1) Virus free seeds of asparagus bean cv. "San-Tse-Chin-Pi" were sowed in insect-proof screenhouse for production of virus free seed. During 4 months cultivation, plants were monthly confirmed by ELISA using antisera against blackeye cowpea mosaic virus (BlCMV) and cucumber mosaic virus (CMV) for their virus free status. If virus-infected plants were detected, they were immediately eradicated from the screenhouse. A seed lot purchased from a local seed company were planted in open field simultaneously as control for the summer experiment. Data were collected approximately 4 months after sowing. Average of pod length and seed no. per pod were measured from a total of 250 fully matured asparagus bean pods. Data of weight per 10^3 seed were from the average of 5 replicates of seed lots. Presence of virus in plants and harvested seeds were determined by ELISA using antisera against BlCMV and CMV.

2) No control plot was planted in spring experiment.

結束時發病率僅30%，而同時期對照區則已100%發病(圖一A)。

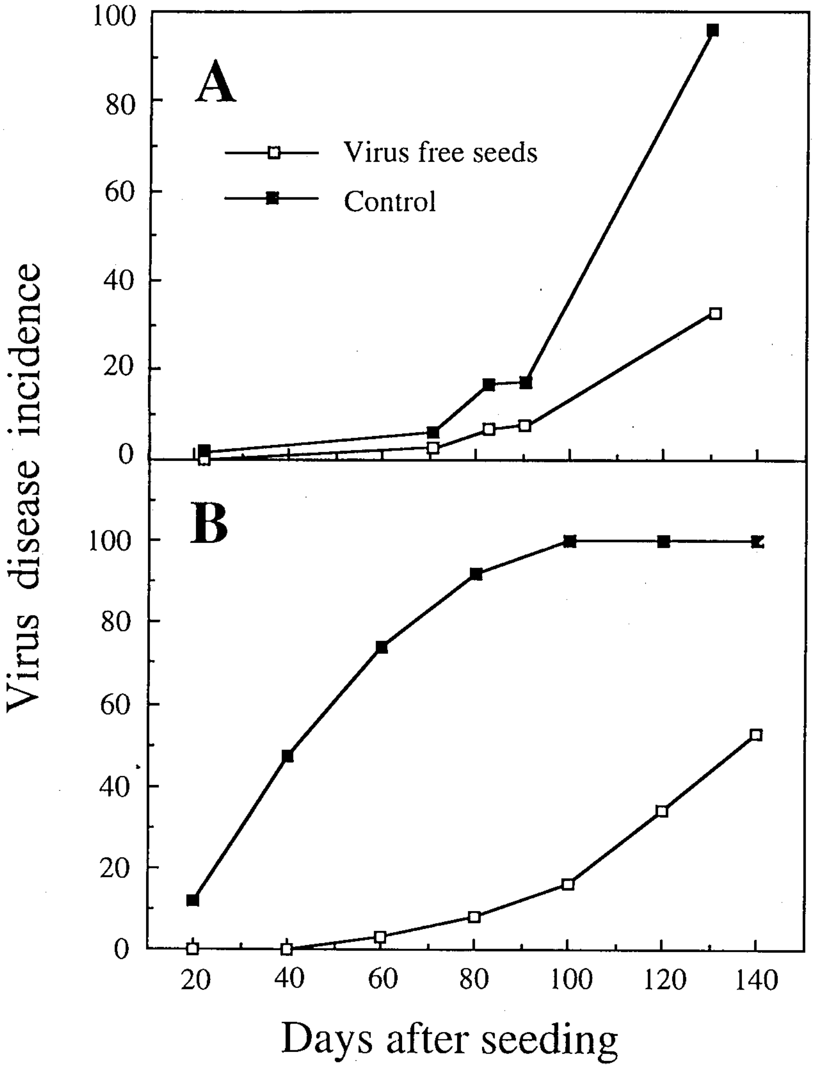
栽培無病毒種子對豇豆產量與收益之影響

爲進一步了解栽培無病毒種子對豇豆產量與農民收益之影響，本研究共分別於屏東高樹、雲林莿桐及彰化溪州三地委託農民進行試作並與當地品系比較產量與收益之差異。結果如表二所示，高樹試區於81年8月進行，因受歐馬颱風侵襲，無病毒種子區全園浸水致初期生長較對照區差，但中期後植株恢復生長勢，統計26次豆莢收穫量，無病毒種子區較對照區高出11%。且由於無病毒種子區所生產之豆莢在品質上優於對照區者，故二者間豆莢平均單價差距達13元，造成總收益間有64%之差異。

同年進行之莿桐試區於11月17日開始採收，由於受低溫影響植株生長勢減弱，無病毒種子區之產量僅較對照區增加13%。期間菜價受季節因素影響全面低迷，無病毒種子區豆莢平均單價僅高出對照區豆莢2元，全期收益增加32%。

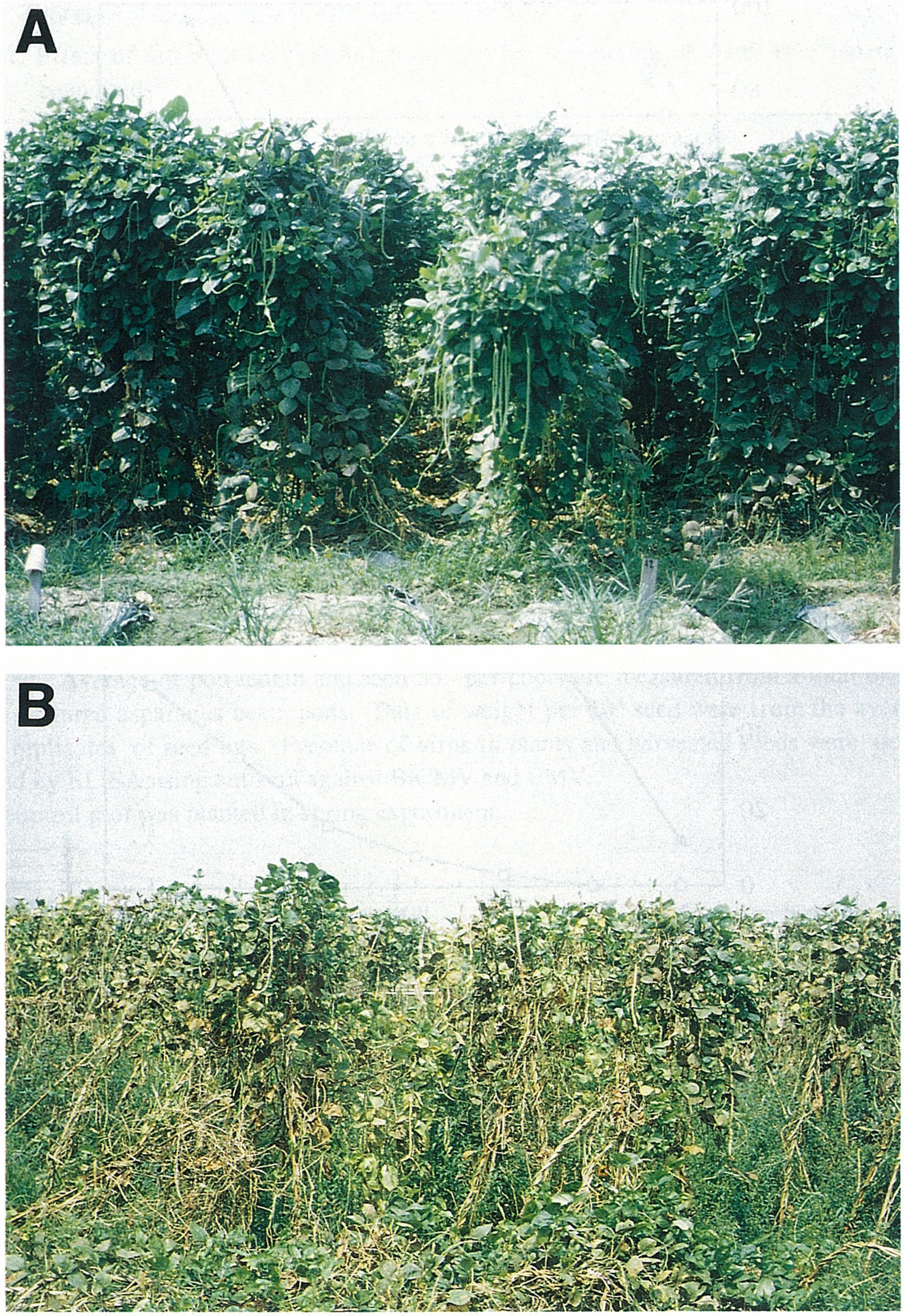
82年2月於彰化溪州所進行之試驗中，無病毒種子區總計產量高出對照區達74%，但因試驗期間適逢水患，在菜價高挺下無法突顯品質之差異，以致此試驗期間無病毒種子區豆莢平均單價略低於對照品系0.7元，收益僅增加73%。

栽培無病毒種子對豇豆豆莢品質之影響調查



圖一、栽植無病毒豇豆種子與商業化帶毒種子對病毒病發病率之影響。圖A爲 1991年於霧峰所進行之田間比較試驗，圖B則爲1992年莿桐試驗。—□—代表栽植無病毒種子試區之病毒再感染率。—■—則代表栽植商業化帶毒種子試區之病毒再感染率。

Fig. 1. Fluctuation of virus disease indidences in asparagus bean plots planted with virus free seeds in comparison to those with commercial seed lots. Two experiments A and B were conducted in Wufeng and Tsztong in Jun. 1991 and Oct. 1992, respectively. Virus free seeds of asparagus bean cv. "San-Tse-Chin-Pi" were sowed in 0.1 ha plots, while same size plots sowing with seed lots purchased from local seed stores were served as control. The distances between the test and control plots were about 100m and 200m for experiment A and B, respectively. The incidences of seed-borne blackeye cowpea mosaic virus (BlCMV) in the commercial seed lots were about 3-4%. Virus disease incidences were determined by ELISA using antisera aganit BlCMV and cucumber mosaic virus on 100 randomly sampled plants.



圖二、栽植無病毒豇豆種子(A)與商業化帶毒種子(B)之試區於播種後120天之生長樹勢比較。

Fig. 2. Photographs showing the difference in the canopy of asparagus bean field 120 days after sowing with virus free asparagus bean seeds (A) as compared to another field sowing with commercial seed lots (B). The photographs were taken from experiment A listed in Fig. 1.

表二、比較栽植無病毒豇豆種子與帶毒種子對豆莢產量與收益之影響

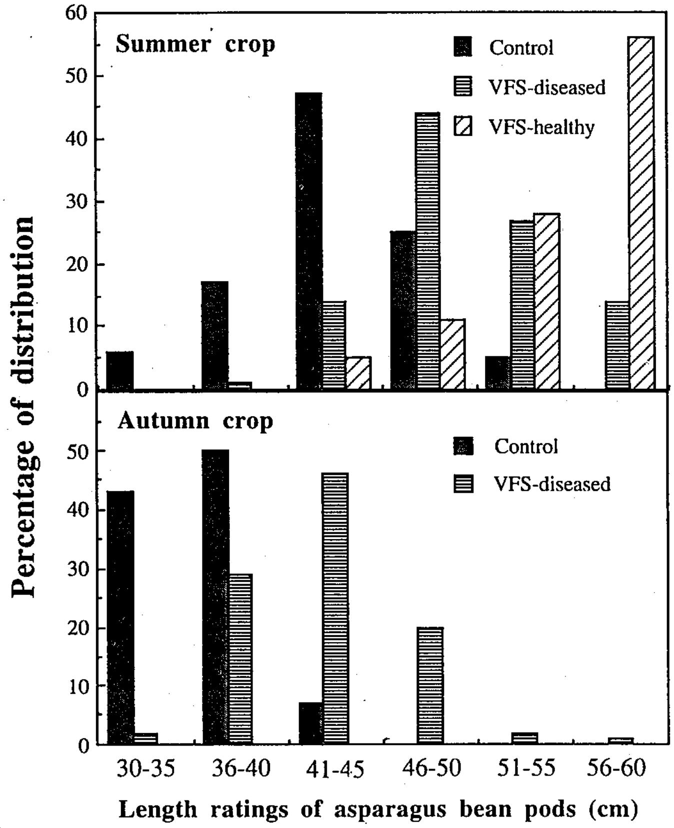
Table 2. Yield and economic profit of asparagus bean harvested from experiment fields sowed with virus free seeds as compared to those obtained from fields planted with virus-infected seed lots[1)]

Influence analysed	Field expriment farm localities, date and harvest period							
	Wufeng Jun. 1991 30 days		Kaosu Aug. 1992 45 days		Tsztong Oct. 1992 50 days		Sietsou Feb. 1993 74 days	
	VF seed	CK	VF seed	CK	VF seed	CK	VF seed	CK
Total yield (Kg/0.1 ha)	561	407	850	765	1400	1235	3811	2191
Yield ratio	1.38	1.00	1.11	1.00	1.13	1.00	1.74	1.00
Unit price (NT/Kg)	–[2)]	–	41.7	28.2	19.3	17.5	21.6	22.3
Total income (NT/0.1 ha)	–	–	35445	21562	26770	20320	79200	45838
Income ratio	–	–	1.64	1.00	1.32	1.00	1.73	1.00
Virus incidence (%)	53	100	67	100	30	100	42	100

[1)] Four field experiments were conducted in the experiment farm of Taiwan Agricultural Research Institute at Wufeng and three other farms in major asparagus bean production areas (Kaosu, Tsztong, and Sietsou) in Taiwan. In each experiment, virus free seeds of asparagus bean cv. "San-Tse-Chin-Pi" were sowed in a 0.1 ha plot which was at least 50 m away from a same size control plot sowed with virus infected seed lot purchased from a local seed store. The seed-borne percentage of the control seed lots was 3-10%. Except the Wufeng experiment in which plants were cultivated and harvested by the researchers, field plants from the other three experiment farms were all grown and harvested by the farmers. Asparagus bean pods harvested by the farmers were auctioned in the local markets. The unit prices were the average of the total income divided by the total yield. Virus incidence was indicated by the % of virus infection out of 100 randomly sampled plants determined by ELISA at the end of each experiment.

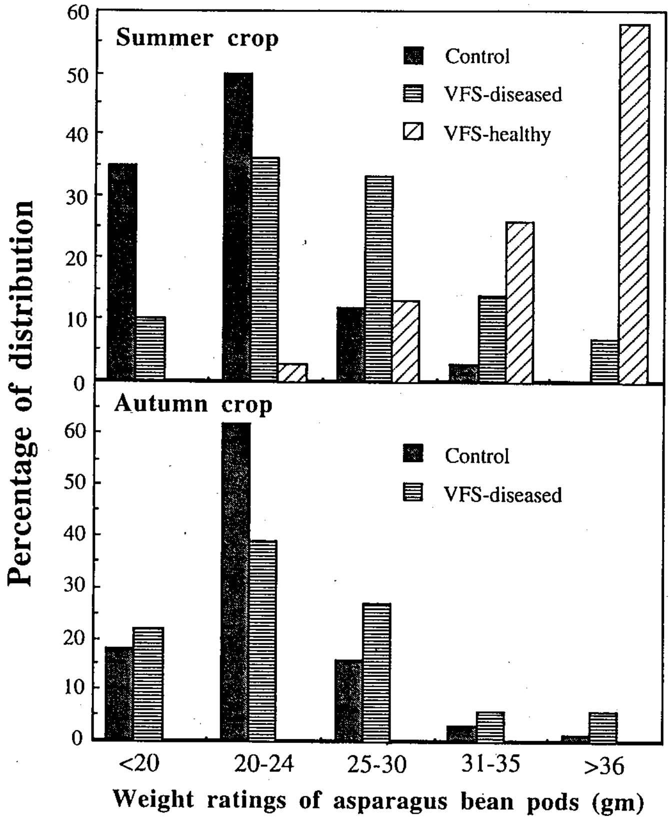
[2)] Data were not recorded.

由於豆莢品質是否可因病毒病之減輕而提升，無法穩定地由豆莢販售之平均單價上看出。因此本研究進一步調查無病毒三尺青皮品系未發病與發病後所生產之豆莢之長度與重量，同時也與農民自留之青皮紫尖品系發病後豆莢之數據比較，以作為判斷豆莢品質變化之依據。由高樹(夏作)及莿桐(秋作)兩試區分別逢機調查無病毒種子試區及對照區收穫之豆莢各100條之長度與重量，另外亦調查本所農場只栽培無病毒種子而後期發病低於1%之夏作豇豆豆莢，而作成長度與重量之分布圖(圖三、四)與平均值(表三)。由圖三顯示夏作於農試所農場單獨栽培無病毒三尺青皮品系時，後期發病率極低(不及1%)，其豆莢長度最多分布於56～60公分，平均可達55.8公分(表三)。而當此品系同時於高樹栽植時，因受附近帶毒種子區影響發病率達到67%，故豆莢長度最高分布區降為46～50公分，平均長度為50.4公分(表三)。但此同時帶毒種子區之對照青皮紫尖品系豆莢長度最高分布區僅為41～45公分，平均43.4公分(表三)。秋作試驗調查結果顯示，由於低溫影響三尺青皮與對照品系之豆莢長度均明顯低於夏作豆



圖三、夏作與秋作栽植無病毒豇豆種子與商業化帶毒種子所收穫之豇豆豆莢長度分布圖。夏作豇豆分別於屏東高樹及霧峰農試所農場進行，前者同時栽植無病毒豇豆種子(VFS-diseased)與市售帶毒種子(Control)各一分地，二區相隔約50公尺。後者只栽植無病毒種子(VFS-healthy)，故採收時發病率不及1%。秋作豇豆於雲林莿桐進行，試區設計與屏東高樹相同亦同時栽植無病毒豇豆種子(VFS-diseased)與市售帶毒種子(Control)各一分地，但二區相隔約200公尺。秋作試驗中並未設只栽植無病毒種子之試區作對照。各試區於收穫時分別逢機量取100條豆莢之長度，作成長度分布圖。

Fig. 3. Length distribution of asparagus bean pods harvested from fields planted with virus free seeds in comparison with those from commercial seed lots. The results were obtained from two experiments conducted respectively in summer and autumn which were the same as listed in Table 3. In the figure, control column indicates the length distribution of bean pods harvested from field plots planting with commercial seed lots, column of VFS-diseased represents those harvested from fields planting with virus free seeds but 30-67% of plants have been infected since they were sowed in a neaby field with commercial seed lots. Columns of VFS-healthy are the length distribution of bean pods harvested from a separate field in Wufeng which only virus free seeds were sowed without infested fields around and the final virus incidence of this field was less than 1%. VFS-healthy was included as control only in summer, but not in autumn, experiment. The percentage of distribution was obtained from a total of 100 asparagus bean pods harvested from each fields.



圖四、夏作與秋作栽植無病毒豇豆種子與市售帶毒種子所收穫之豇豆豆莢重量分布圖。夏作豇豆分別於屏東高樹及霧峰農試所農場進行，前者同時栽植無病毒豇豆種子(VFS-diseased)與市售帶毒種子(Control)各一分地，二區相隔約50公尺。後者只栽植無病毒種子(VFS-healthy)，故採收時發病率不及1%。秋作豇豆於雲林莿桐進行，試區設計與屏東高樹相同亦同時栽植無病毒豇豆種子(VFS-diseased)與市售帶毒種子(Control)各一分地，但二區相隔約200公尺。秋作試驗中並未設只栽植無病毒種子之試區作對照。各試區於收穫時分別逢機量取100條豆莢之重量，作成重量分布圖。

Fig. 4. Weight distribution of asparagus bean pods harvested from fields planted with virus free seeds in comparison with those from commercial seed lots. The results were obtained from two experiments conducted respectively in summer and autumn which were the same as listed in Table 3. In the figure, control column indicates the weight distribution of bean pods harvested from field plots planted with commercial seed lots, while column of VFS-diseased represents those harvested from fields planted with virus free seeds but 30-67% of plants have been infected since they were sowed simultaneously in a neaby field with commercial seed lots. Columns of VFS-healthy are the weight distribution of bean pods harvested from a separate field in Wufeng which only virus free seeds were sowed without infested fields around and the final virus incidence of this field was less than 1%. VFS-healthy was included as control only in summer, but not in autumn, experiment. The percentage of distribution was obtained from a total of 100 asparagus bean pods harvested from each fields.

莢，但發病率僅30%之無病毒種子試區豆莢長度仍高出發病達100%之對照區豆莢，二者平均長度差異達7公分(表三)。本試驗秋作並未單獨栽植三尺青皮品系作爲對照。

調查豆莢重量時則如圖四所示，發病極低之三尺青皮品系夏作豆莢重量最多分布於36～40公克，平均達37.7公克(表三)。同時期此品系發病67%後，豆莢單重有偏低現象，最多僅分布於20～24公克，平均莢重26.3公克(表三)。而同時期對照品系之莢重最高雖亦分布於20～24公克間，但其大部分豆莢都分布於20～24公克以下，而三尺青皮之豆莢則大都分布於20～24公克以上，部分豆莢甚至達到36公克以上(圖四)。且對照品系之總平均莢重低於三尺青皮5公克(表三)。秋作調查結果與夏作類似，二品系之莢重最高分布區均於20～24公克間，但超過此範圍之豆莢數目則三尺青皮遠大於對照品系(圖四)，而且在平均莢重上三尺青皮者亦高出對照品系約2公克(表三)。

討　論

本省豇豆栽培過程中罹患病毒病害而影響植株之生長與結莢乃極爲普遍之現象[3,9]。爲了解豇豆病毒病之發生生態及傳染源來源，本實驗室曾連續進行二年之田間病毒發生調查，結果發現本省豇豆主要受BlCMV及CMV二種病毒之危害，其中CMV必需仰賴高密度之蚜蟲，才能由其他作物傳至豇豆進而造成流行。而BlCMV則因本省商業化豇豆種子中帶BlCMV比率偏高影響，縱使在蚜蟲密度偏低下仍可年年嚴重危害豇豆(張清安，未發表資料)。因而啓發利用無病毒種子防治豇豆病毒病之構想。本研究共進行四次田間比較試驗，除第一次試驗是在農試所農場進行外，其餘三次均委託農民以當地習慣栽培。結果在涵蓋本省四個主要豇豆生產地區與春夏秋三個主要栽培期下，四個試驗均一致證實栽植無病毒種子有延緩並減輕豇豆病毒病之效果，另外豇豆之產量與農民收益也可因病毒病之減輕而提升。雖然試驗

表三、比較栽植無病毒豇豆種子與帶毒種子對豆莢重量與長度之影響

Table 2. Length and weight of asparagus bean pods harvested from experiment fields sowed with virus free seeds as compared to those obtained from fields planted with commercial seed lots[1)]

Influence analysed	Season and locality of experiment farm					
	Summer				Autumn	
	Kaosu		Wufeng		Tsztong	
	VF-seed	Control	VF-seed	Control	VF-seed	Control
Virus incidence (%)	67	100	< 1	–[2)]	30	100
Av. pod length (cm)	50.4	43.4	55.8	–	43.0	35.7
Av. pod weight (gm)	26.3	21.1	37.7	–	24.1	22.3

1) The experiments conducted in Kaosu and Tsztong were the same ones as listed in Table 2. Average pod length and weight were calculated from 3 replicates, each with 100 asparagus bean pods randomly sampled from different harvests. Virus incidence was indicated by the % of virus infection out of 100 randomly sampled plants determined by ELISA at the end of each experiment.

2) In Wufeng experiment, only virus free seeds of cv. "San-Tse-Chin-Pi" were sowed in a 0.1 ha plot without control plot planted with commercial virus infected seed lot.

規劃時礙於無法取得有部分種子帶毒之商業化三尺青皮品系種子之現實，而不得已採用各項性質極接近之青皮紫尖品系作爲對照，造成試驗結果中產量之差異也可能由於品系間之不同所引起，但是根據過去栽培經驗，豇豆品系間產量差異並不明顯，因此後期由於種子帶毒與否所造成之病毒病發生率之截然不同，應該是造成產量差異之一項不可忽視之重要因素。

所進行之四次田間試驗中，除第一次因農試所農場所生產之豇豆無法銷售外，其餘三次試驗無病毒種子區之豆莢總收益均高出對照區 32～73%。歸究其因，除因病毒發生率下降而產量提升外，豆莢品質之提升造成單價較對照品種高也是原因之一。豆莢品質之提升除受益於病毒病之減輕外，本試驗三尺青皮品系之豆莢較對照品系受到消費者歡迎也是可能因素。不過此情況並非絕對如此，在第四次溪洲試驗中當地市場即對"三尺青皮"不特別偏好，造成其平均單價稍低於對照之青皮紫尖品系(表二)。由於豆莢品質之是否提升無法絕對由販售單價中分辨，因此本研究特別再進行豆莢長度與重量之比對調查，結果在夏秋兩季均一致發現無病毒種子區之豆莢在長度及重量上均優於發病達100%之對照品系，而且當無病毒"三尺青皮"品系單獨栽培時其季末發病率低於1%下，其豆莢之長度與重量也顯著高於同時期栽培而發病率達67%之相同品系，由此印證病毒病之發生確實對豆莢之品質有明顯之影響。

已知由種子帶病毒所引發之病害種類極爲普遍[6,9]，然而能夠以栽培無病毒種子成功防治的例子實在不多[6]。1975年Kimble等人利用無病毒萵苣種子成功防治由萵苣嵌紋病毒(Lettuce mosaic virus)所造成之嚴重損失[10]，應屬最早之成功先例。無病毒種子栽植後之再感染病毒速率太快，而不具減緩病害提高產量之效果，爲造成不易防治成功之最主要因素[6,9,10]。無病毒種子栽培後之再感染速率，視病毒種類而有差異。通常寄主範圍廣，可隨時存在於田間寄主上之病毒，其傳播之可能性較寄主範圍窄之病毒高出很多[6,9,10]。本研究之所以能夠以無病毒種子降低豇豆病毒病之發生也可能是由於BlCMV之寄主範圍較窄，傳播之可能性較低所致。除豇豆外，BlCMV可能危害之作物僅限於皇帝豆與紅豆二種[6,8]，而此二作物由於栽培習性偏好冷涼氣候，通常與豇豆不會同時存在田間，故相互傳染病毒之可能性極低。至於另一個防治對象病毒CMV，雖然其寄主範圍甚廣，但是在豇豆主要生產季節之夏季裡由於蚜蟲密度偏低，其傳播較不明顯，故豇豆受CMV之威脅並不大。然而如果豇豆種子中帶有BlCMV時，萬一CMV被蚜蟲傳播至豇豆而與BlCMV發生複合感染，則因相乘作用(Synergism)之發生[2]，病毒即會快速流行，對豇豆生產造成嚴重威脅。因此只要能去除種子中之BlCMV感染源，則不僅BlCMV無法快速流行危害豇豆，縱使CMV被蚜蟲傳至，兩者發生復合感染之機會也相對降低，不致於造成病毒病之流行。

在四次田間試驗中爲避免無病毒種子試區受對照區病源之影響，我們儘可能將兩試區之間隔距離拉長，但很顯然此種影響仍然存在。因爲我們曾經在農試所農場只栽植無病毒種子而不栽植對照帶毒種子下，發現季末發病率不及1%。而四次田間試驗均因帶毒種子之病毒感染源影響，使無病毒種子區之季末發病率達到30～67%。而且此四次試驗中以高樹試驗之無病毒種子區與對照種子區之距離50公尺最近，結果也以此試驗之無病毒種子試區67%發病率最高。反之莿桐試驗中兩試區之距離爲200公

尺，其發病率也因而只有30%。此結果進一步顯示豇豆病毒病之發生與其種子帶毒之感染源有密切關係。由於目前絕大多數農民仍然栽培商業化種子或自行留種使用，在豇豆病毒感染源仍普遍存在本省田間之情形下，栽培無病毒種子尚無法全面杜絕病毒病之發生，但由於豇豆乃短期蔬菜作物，病毒病發生之延遲，即意謂著到達收穫期時，健全植株之比例會因而提高，豆莢產量與品質必然相對提升。而且只要透過進一步推廣，適度擴大無病毒豇豆種子之栽種面積，則豇豆病毒病發生之壓力即可能因病毒感染源之進一步減少而逐漸減緩。但是透過適當的推廣教育，宣導農民不再自行留種，使栽植高品質種子之觀念能進一步落實，則是延續此項防治成果之必要配合措施。

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ABSTRACT

Chang, C. A.[1], Yang, T. T.[2], Tsan, T. M.[2], and Chen, C. C.[1] 1994. Production and application of virus free seeds to control virus diseases of asparagus beans. Plant Prot. Bull. 36:313-325. (Taiwan Agricultural Research Institute, Taichung 41301, Taiwan, ROC)

Asparagus bean [*Vigna unguiculata* (L.) Walp. ssp. *sesquipedalis* (L.) Verdc.] is one of the important vegetables in Taiwan in hot and wet summer season. Among various kinds of diseases attacking asparagus bean, virus diseases are recognized as major limiting factors for its production. Cucumber mosaic virus (CMV) and blackeye cowpea mosaic virus (BlCMV) were previously found as the two major viruses attacking asparagus bean in fields. Both viruses were found seed-borne and the infected seedlings could serve as primary inoculum for the consequent early epidemic as resulted from mechanical and aphid transmission. This investigation was directed to evaluate the effects of planting virus free asparagus bean seeds in controlling the viruses in fields. An asparagus bean cultivar "San-Tse-Chin-Pi" was selected for production of virus free seeds in 1990. By roguing virus-infected plants after detection by ELISA using antisera against BlCMV and CMV, plants were cultivated in insect proof screenhouse until seeds were harvested, which were then served as foundation virus free stock. A large-scale virus free seed propagation system was subsequently developed in order to sufficiently satisfy the demand from the growers in Taiwan. In 1991-1992 we conducted four field trials to test the feasibility of using virus free seeds to control virus disease of asparagus bean and found that the application not only significantly delayed the development of the virus disease epidemic but also increased the yield and quality of bean pods and eventually the economic profit. In the field experiments, as low as 30-72% of final virus incidences were recorded in the plots sowed with virus free seeds while in the same time 100% of incidences were detected in the control plots planted with commercial seed lots. The increase of yield and profit of bean pods in the test plots were 11-74% and 32-73% higher than those of the control plots, respectively.

(Key words: asparagus bean, virus, virus free seed, virus control)